US009917931B2

(12) **United States Patent**
Adachi et al.

(10) **Patent No.: US 9,917,931 B2**
(45) **Date of Patent: *Mar. 13, 2018**

(54) **RADIO COMMUNICATION SYSTEM, RADIO APPARATUS, RADIO COMMUNICATION METHOD, PACKET GENERATION METHOD, AND METHOD FOR REPRODUCING DATA FROM PACKET**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 105 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **15/045,535**

(22) Filed: **Feb. 17, 2016**

(65) **Prior Publication Data**

US 2016/0247505 A1 Aug. 25, 2016

(30) **Foreign Application Priority Data**

Feb. 19, 2015 (JP) 2015-030811

(51) **Int. Cl.**
H04L 29/06 (2006.01)
H04W 4/10 (2009.01)
G10L 19/16 (2013.01)

(52) **U.S. Cl.**
CPC ***H04L 69/22*** (2013.01); *G10L 19/167* (2013.01); *H04W 4/10* (2013.01)

(58) **Field of Classification Search**
CPC H04W 4/10; H04W 72/005; H04W 84/20; H04L 69/22; H04L 1/0048; H04L 1/006; H04L 1/0065; H04L 1/005; G10L 19/167; G10L 19/22; G10L 19/008; G10L 19/00
USPC 370/474, 389
See application file for complete search history.

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(57) **ABSTRACT**

A transmission unit of a radio apparatus generates a packet including: a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another. When communication is performed in a fast data mode in which data for data communication to be transmitted, instead of a digital audio signal, is inserted in the audio frame, the transmission unit generates, according to an instruction from the controller, a packet in which data for data communication is inserted in the audio frame and the data frame, and the transmission unit converts the packet into a radio signal and transmits the radio signal.

20 Claims, 7 Drawing Sheets

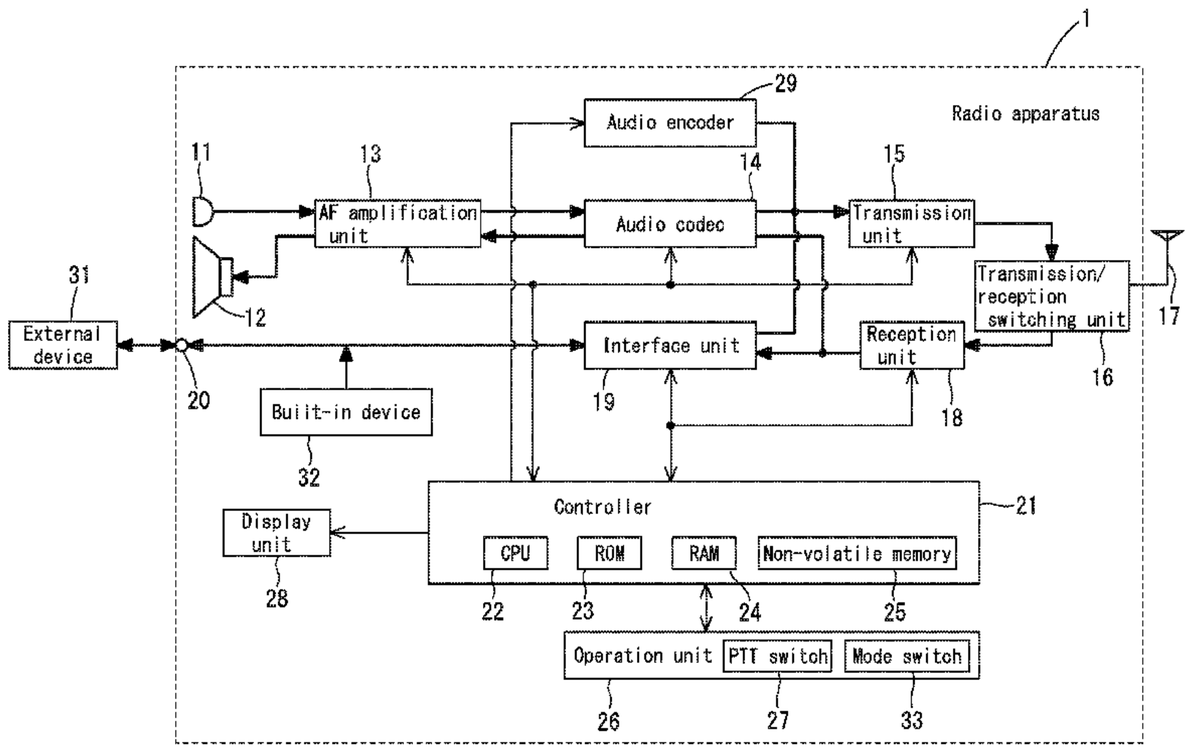

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FIG. 1

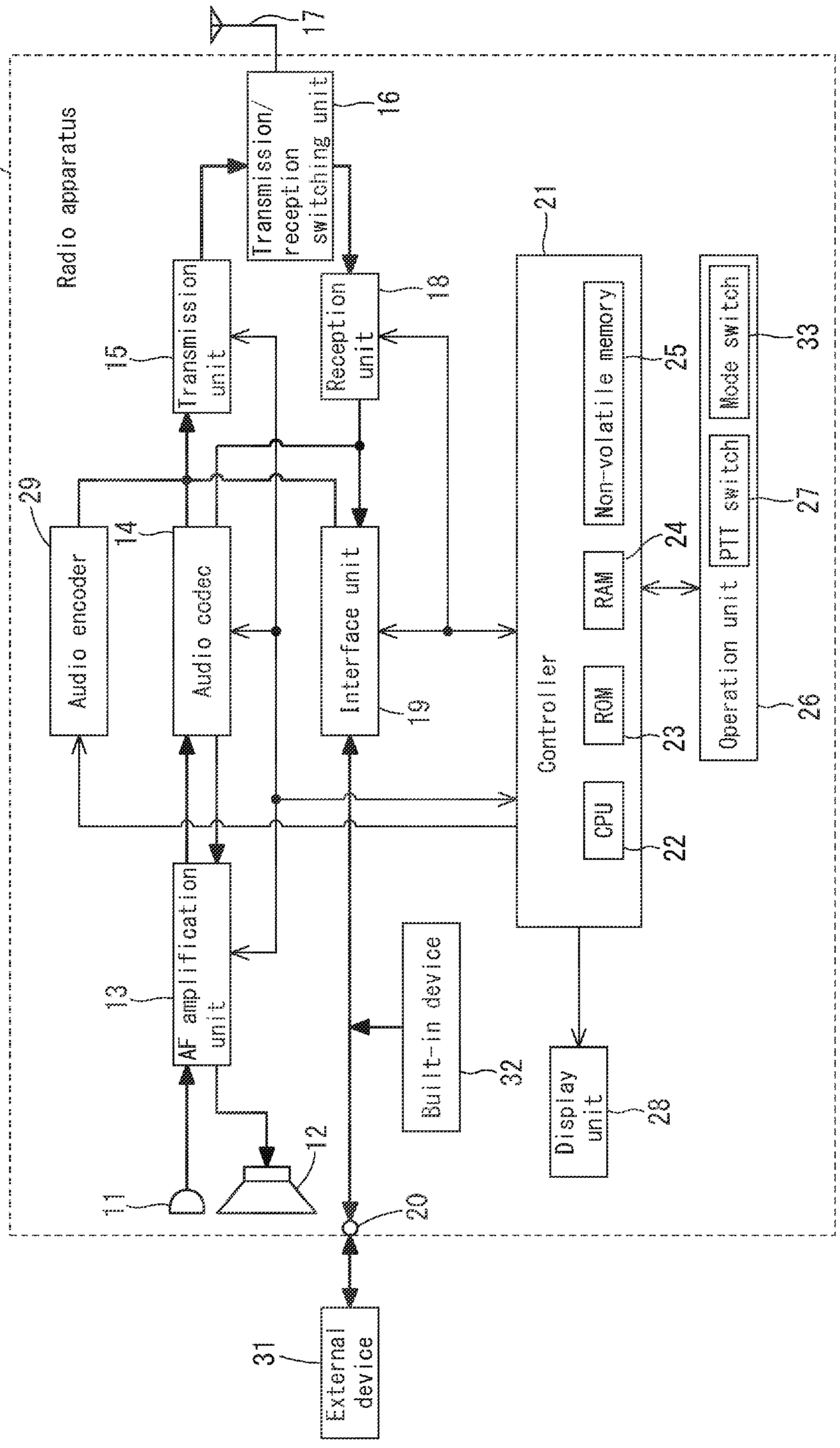

1
Radio apparatus
17
Transmission/ reception switching unit
16
21
Transmission unit
15
Reception unit
18
29
Audio encoder
14
Audio codec
Interface unit
19
Controller
Non-volatile memory
25
RAM
24
ROM
23
CPU
22
Mode switch
33
PTT switch
27
Operation unit
26
AF amplification unit
13
Built-in device
32
Display unit
28
11
12
20
External device
31

FIG. 2

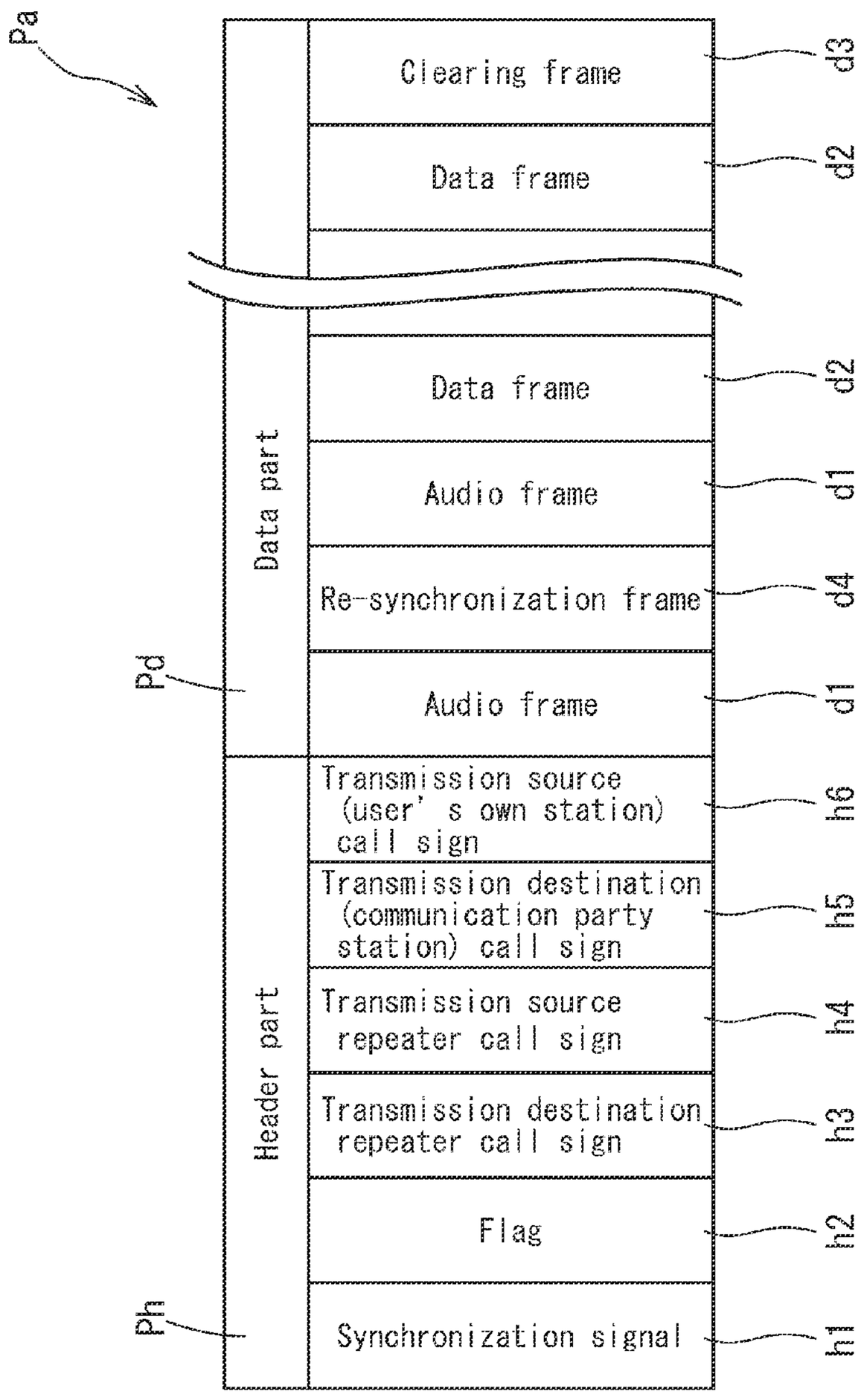

Pa
Clearing frame
d3
Data frame
d2
Data frame
d2
Audio frame
d1
Re-synchronization frame
d4
Audio frame
d1
Pd
Data part
Transmission source (user's own station) call sign
h6
Transmission destination (communication party station) call sign
h5
Transmission source repeater call sign
h4
Transmission destination repeater call sign
h3
Flag
h2
Synchronization signal
h1
Ph
Header part

FIG. 3

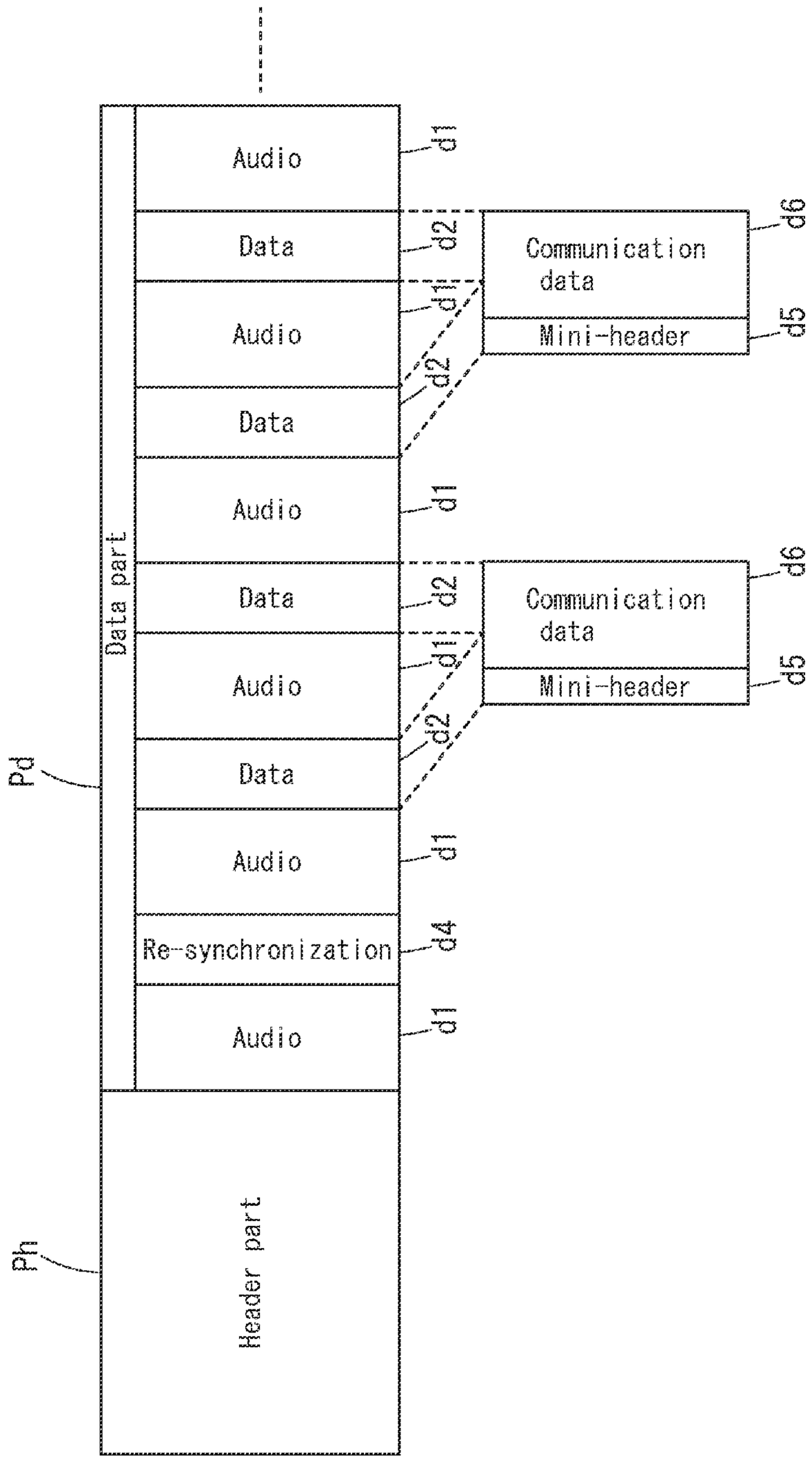

Pd
Data part
Audio
d1
Data
d2
Communication data
d6
Mini-header
d5
Re-synchronization
d4
Ph
Header part

FIG. 4

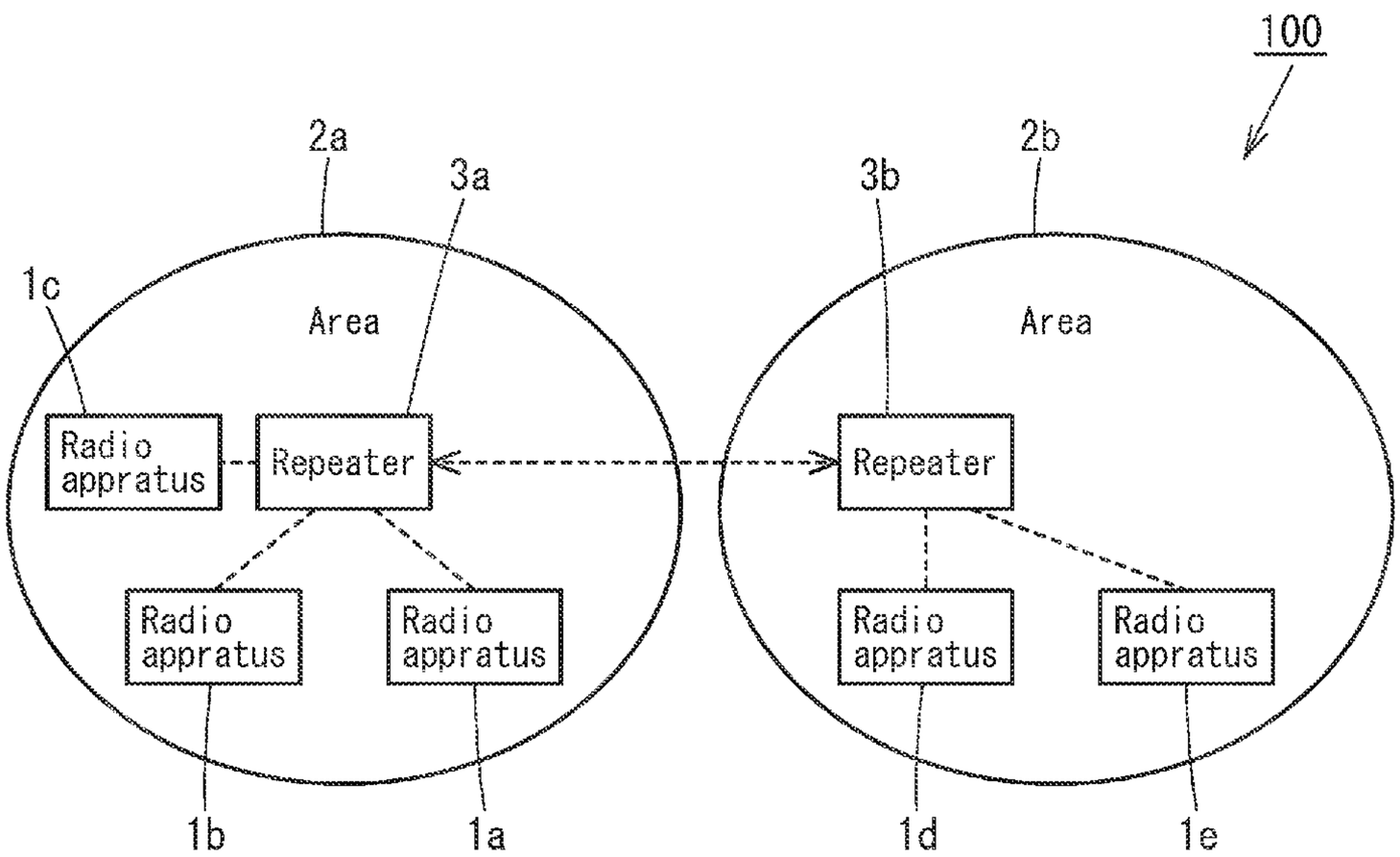

100
2a
3a
2b
3b
1c
Area
Area
Radio appratus
Repeater
Repeater
Radio appratus
Radio appratus
Radio appratus
Radio appratus
1b
1a
1d
1e

FIG. 5

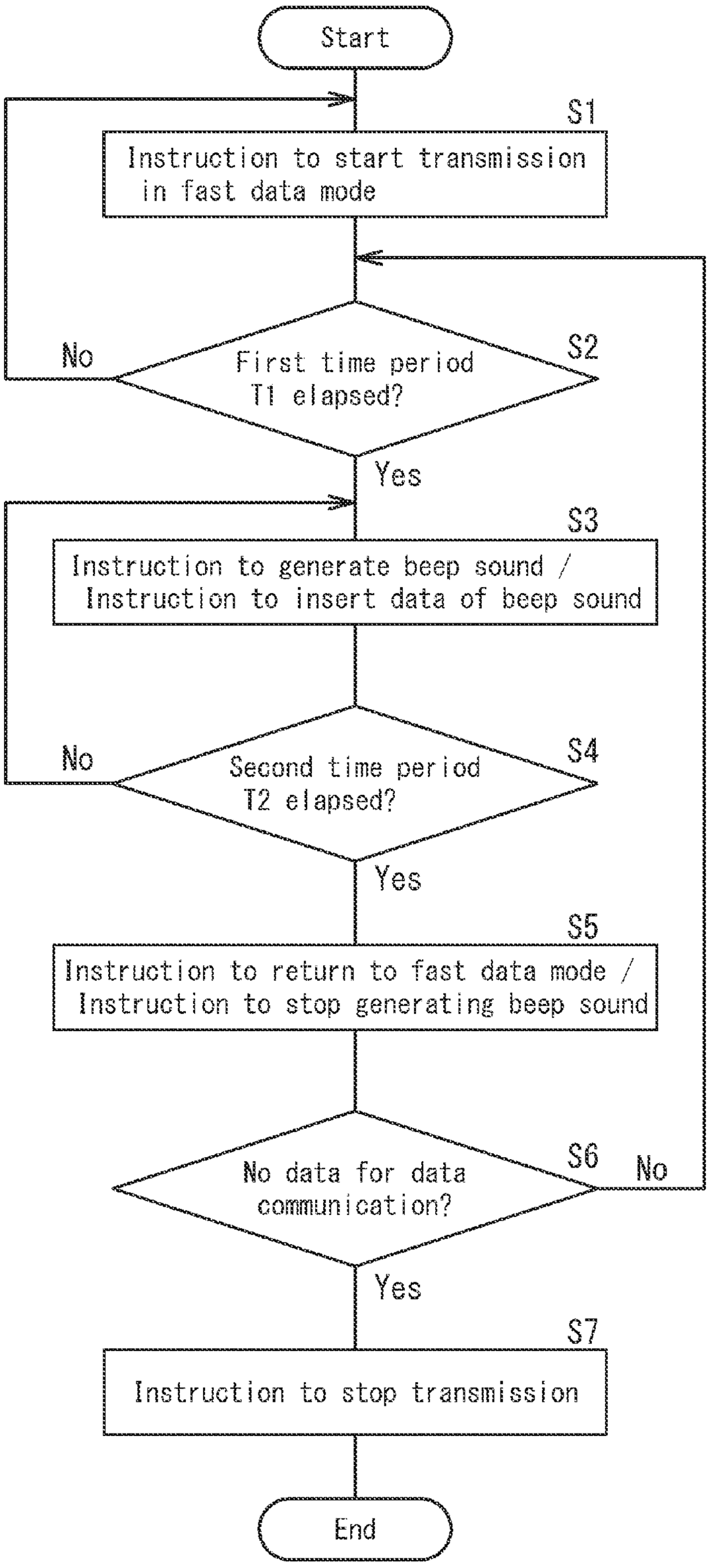
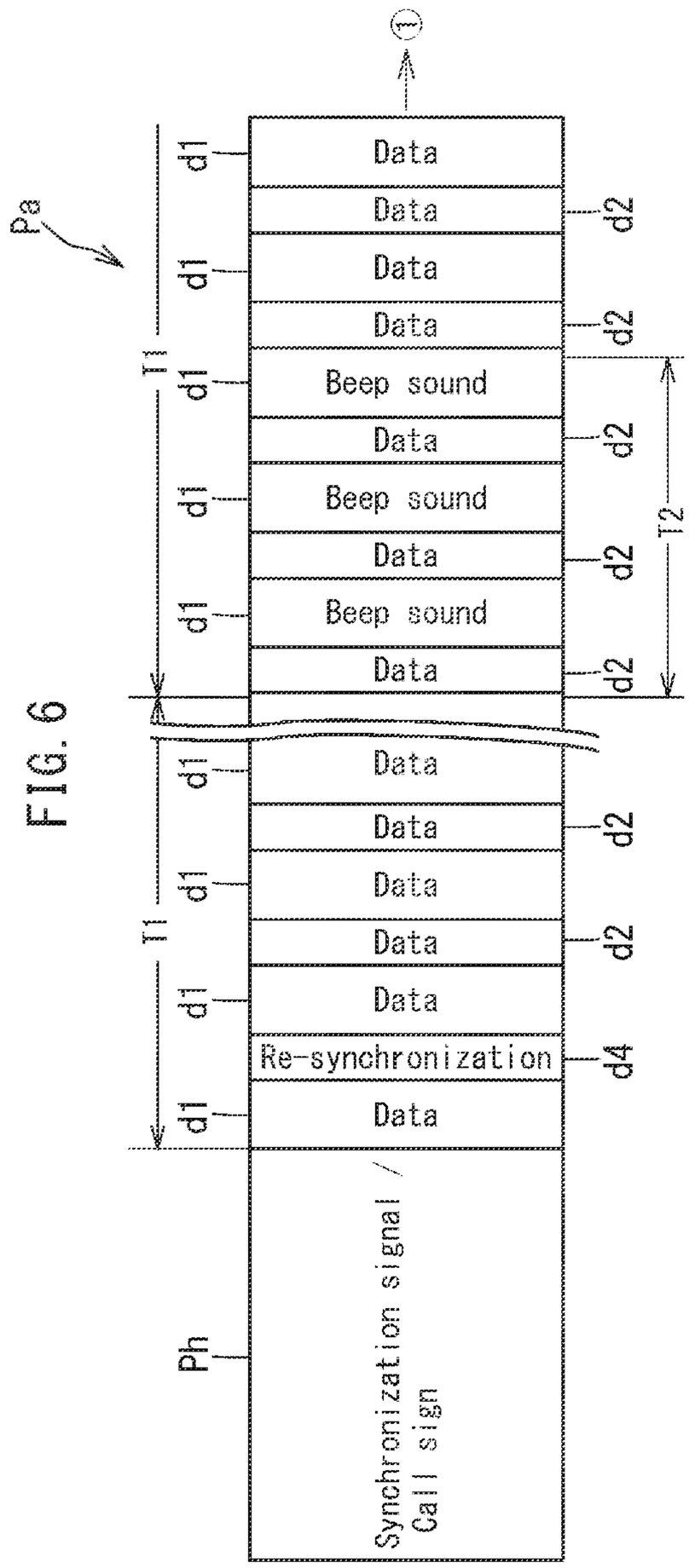

Start
S1
Instruction to start transmission in fast data mode
S2
First time period T1 elapsed?
No
Yes
S3
Instruction to generate beep sound / Instruction to insert data of beep sound
S4
Second time period T2 elapsed?
No
Yes
S5
Instruction to return to fast data mode / Instruction to stop generating beep sound
S6
No data for data communication?
No
Yes
S7
Instruction to stop transmission
End

FIG. 6


Pa
Ph
T1
T2
d1
d2
d3
d4
Data
Beep sound
Re-synchronization
Clearing
Synchronization signal / Call sign
①

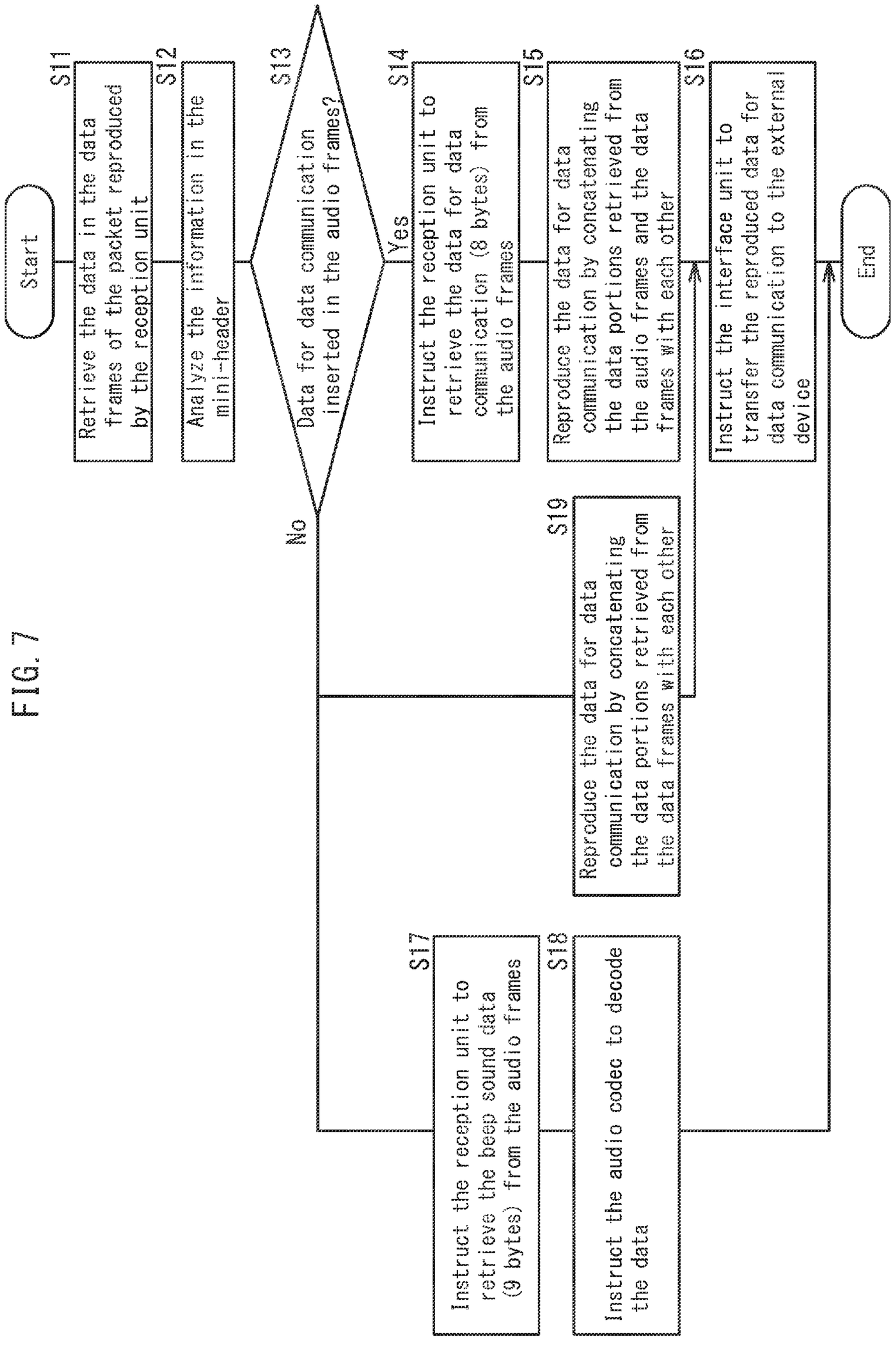

Start
S11
Retrieve the data in the data frames of the packet reproduced by the reception unit
S12
Analyze the information in the mini-header
S13
Data for data communication inserted in the audio frames?
Yes
No
S14
Instruct the reception unit to retrieve the data for data communication (8 bytes) from the audio frames
S15
Reproduce the data for data communication by concatenating the data portions retrieved from the audio frames and the data frames with each other
S16
Instruct the interface unit to transfer the reproduced data for data communication to the external device
End
S19
Reproduce the data for data communication by concatenating the data portions retrieved from the data frames with each other
S17
Instruct the reception unit to retrieve the beep sound data (9 bytes) from the audio frames
S18
Instruct the audio codec to decode the data

FIG. 7

RADIO COMMUNICATION SYSTEM, RADIO APPARATUS, RADIO COMMUNICATION METHOD, PACKET GENERATION METHOD, AND METHOD FOR REPRODUCING DATA FROM PACKET

CROSS REFERENCE TO RELATED APPLICATIONS

The disclosure of Japanese Patent Application serial No. 2015-30811, filed on Feb. 19, 2015, including the specification, drawings and abstract is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a radio communication system employing digital audio communication, a radio apparatus used in the system, and a radio communication method, a packet data generation method, and a method for reproducing data from a packet, that correspond to the system.

Description of the Related Art

In recent years, a digitized and networked environment for audio communication has been developing in the field of amateur radio for example, so that the users can enjoy communication at higher speed and exchange clearer audio messages. In a radio communication system employing such digital audio communication, audio signals are encoded and converted into digital signals, and are transmitted after being packetized (for example, see JP 2006-157477A).

In the aforementioned radio communication system, data indicating a call sign of the transmission destination, data indicating a call sign of the transmission source, etc. are added to the header part of the packet, and accordingly the system can achieve many functions such as the function of performing communication with the designation of the communication party station, which cannot be achieved by analogue radio communication systems.

Furthermore, according to the aforementioned radio communication system, audio frames and data frames, each having a predetermined length, are consecutively arranged one after the other, so that data for audio communication and data for data communication can be simultaneously transmitted.

Therefore, with use of this function, image signals captured by a camera can be transmitted from one radio apparatus to another radio apparatus during communication, so that the image is displayed on a display and the users can enjoy a conversation while seeing the image, for example.

However, the aforementioned conventional radio communication system is designed for audio communication, and the amount of data that can be transmitted in data communication is set to be smaller than the amount of data that can be transmitted by audio communication, and the communication speed of the data communication is not necessarily high. Therefore, improvement has been demanded.

BRIEF SUMMARY OF THE INVENTION

The present invention is made in view of such a situation, and aims to provide a radio communication system that can increase the communication speed of data communication.

A radio communication system according to the present invention is a radio communication system including at least two radio apparatuses,

each radio apparatus comprising:

a transmission unit configured to generate a packet including: a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another, to insert audio signal data into the audio frame of the packet and to insert data other than the audio signal data into the data frame of the packet, and to thereafter convert the packet into a radio signal and transmit the radio signal;

a reception unit configured to receive the radio signal, to reproduce a packet from the radio signal, to retrieve the audio signal data from the audio frame of the packet, and to retrieve the data other than the audio signal data from the data frame of the packet;

an audio codec configured to generate a digital audio signal by performing A/D conversion and encoding on an analogue audio signal and thereafter transmit the digital audio signal to the transmission unit, and to reproduce an analogue audio signal by performing decoding and D/A conversion on a digital audio signal received from the reception unit; and

a controller configured to instruct the transmission unit to generate a packet, and to instruct the reception unit to reproduce a packet from a received radio signal,

wherein, when communication is performed in a fast data mode in which data for data communication to be transmitted, instead of audio signal data, is inserted in the audio frame,

the transmission unit of a radio apparatus serving as a sender generates, according to an instruction from the controller, a packet in which data for data communication is inserted in the audio frame and the data frame, and information indicating that the data for data communication is inserted in the audio frame is further inserted in a predetermined position in the data frame, and

the controller of a radio apparatus serving as a recipient, which has received a radio signal, analyzes the information inserted in the predetermined position in the data frame of the packet reproduced by the reception unit, to determine that the data for data communication is inserted in the audio frame, and according to a result of the determination, retrieves data from the audio frame and the data frame of the packet and reproduces the data for data communication.

A radio apparatus according to the present invention is a radio apparatus comprising:

a transmission unit configured to generate a packet including: a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another, to insert audio signal data into the audio frame of the packet and to insert data other than the audio signal data into the data frame of the packet, and to thereafter convert the packet into a radio signal and transmit the radio signal;

an audio codec configured to generate a digital audio signal by performing A/D conversion and encoding on an analogue audio signal and thereafter transmit the digital audio signal to the transmission unit; and

a controller configured to instruct the transmission unit to generate a packet,

wherein, when communication is performed in a fast data mode in which data for data communication to be transmitted, instead of audio signal data, is inserted in the audio frame,

the transmission unit generates, according to an instruction from the controller, a packet in which data for data communication is inserted in the audio frame and the data frame, and information indicating that the data for data communication is inserted in a predetermined position in the audio frame is further inserted in the data frame.

A radio communication method according to the present invention is a radio communication method for a radio communication system including at least two radio apparatuses, one of the at least two radio apparatuses being configured to generate a packet including: a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another, and to convert the packet into a radio signal and transmit the radio signal, and another one of the at least two radio apparatuses being configured to receive the radio signal and reproduce a packet from the received radio signal, the radio communication method comprising the steps of:

with a radio apparatus serving as a sender,

generating a packet in which data for data communication is inserted in the audio frame and the data frame, and information indicating that the data for data communication is inserted in the audio frame is inserted in the data frame; and

converting the generated packet into a radio signal and transmitting the radio signal, and

with a radio apparatus serving as a recipient,

receiving the radio signal;

reproducing a packet from the received radio signal;

analyzing information that is inserted in the data frame of the reproduced packet to determine whether or not data for data communication is inserted in the audio frame; and

when determining that the data for data communication is inserted in the audio frame, retrieving data from the audio frame and the data frame of the packet and reproducing the data for data communication.

A packet generation method according to the present invention is a packet generation method for a radio apparatus that performs communication with another radio apparatus by using a packet that includes: a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another, the packet generation method comprising the steps of:

inserting data for data communication into the audio frame and the data frame; and

inserting, into the data frame, information indicating that the data for data communication is inserted in the audio frame.

A method for reproducing data from a packet performed by a radio apparatus according to the present invention is a method for reproducing data from a packet performed by a radio apparatus that is configured to receive a radio signal containing a packet generated by the above-described packet generation method, and to reproduce the packet from the radio signal, the method comprising the steps of:

analyzing information that is inserted in the data frame of the reproduced packet to determine whether or not data for data communication is inserted in the audio frame; and

when determining that the data for data communication is inserted in the audio frame, retrieving data from the audio frame and the data frame of the packet and reproducing the data for data communication.

Employing the radio communication system according to the present invention increases the communication speed of data communication, and achieves higher speed transmission of data for data communication compared to conventional radio communication systems.

Also, the functions realized by the above-described radio communication system can be realized by the radio apparatus, the radio communication method, the packet generation method, and the method for reproducing data from a packet according to the present invention, using a similar configuration or method.

These and other objects, features and advantages of the present invention will become more apparent upon reading of the following detailed description along with the accompanied drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing a configuration of a radio apparatus according to an embodiment of the present invention.

FIG. **2** is a diagram showing a configuration of a packet transmitted by a radio apparatus.

FIG. **3** is a diagram showing types of data to be inserted in frames of the data part of a packet.

FIG. **4** is a diagram showing an arrangement of radio apparatuses and repeaters in a radio communication system according to an embodiment of the present invention.

FIG. **5** is a flowchart showing processing performed by a controller from the start to the end of a packet transmission in a fast data mode.

FIG. **6** is a diagram showing types of data to be inserted in a packet in the mode.

FIG. **7** is a flowchart showing processing performed by the controller of a radio apparatus that has received a packet.

DETAILED DESCRIPTION OF THE INVENTION

The following describes a radio communication system according to an embodiment of the present invention, with reference to the drawings.

Measures to Increase Communication Speed of Data Communication

First, a description is given of a measure adopted in the present invention to increase the communication speed of data communication. The present invention increases the communication speed of data communication by inserting data to be transmitted in data communication into audio frames used for transmitting audio signal data.

In the following description, the communication mode in which audio signal data is inserted into audio frames is referred to as “slow data mode”, and the communication mode in which data for data communication is inserted into audio frames is referred to as “fast data mode”, based on the difference in communication speed of the data communication.

When a transmission is performed in the fast data mode, which is selected from the above-described two communication modes, the receiver does not reproduce a sound and becomes silent. Therefore, if a device for displaying the

communication data is not connected to the radio apparatus, there will be no way to distinguish between communication in the fast data mode and silent communication.

Furthermore, when a conventional radio apparatus that does not support the fast data mode receives a fast data mode packet, the radio apparatus cannot reproduce the data for data communication from the packet, and accordingly the user may misidentify the communication as silent interferential communication.

For this reason, according to the present invention, the radio apparatus that has received radio signals in the fast data mode is caused to output a beep sound at constant intervals, from its speaker, in order to notify the user that communication is performed in the fast data mode.

Therefore, the user of the radio apparatus (the communication party station) that has received radio signals can easily recognize that communication is performed in the fast data mode, from the beep sounds that are output periodically. This effect is beneficial particularly when a radio apparatus not supporting the fast data mode receives radio signals.

Configuration of Radio Apparatus

Next, with reference to FIG. **1**, a description is given of a radio apparatus used in a radio communication system according to the present embodiment. A radio apparatus **1** includes a microphone **11**, a speaker **12**, an AF amplification unit **13**, an audio codec **14**, a transmission unit **15**, a transmission/reception switching unit **16**, an antenna **17**, a reception unit **18**, an interface unit **19**, a controller **21**, an operation unit **26**, and a display unit **28**. In the drawing, thick arrows indicate the flow of an audio signal, data, etc., and thin arrows indicate the flow of a control system signal.

The microphone **11** generates an analogue audio signal from an audio input, and outputs the audio signal to the AF amplification unit **13**. The speaker **12** converts an analogue audio signal output from the AF amplification unit **13**, to a sound.

The AF (Audio Frequency) amplification unit **13** amplifies an analogue audio signal input from the microphone **11**, and supplies the resultant signal to the audio codec **14**. The AF amplification unit **13** also amplifies an analogue audio signal of a reception sound supplied from the audio codec **14**, and outputs the resultant signal to the speaker **12**.

The audio codec **14** performs an A/D (analogue/digital) conversion and encoding on an analogue audio signal supplied from the AF amplification unit **13**, and outputs the resultant signal to the transmission unit **15**. The audio codec **14** also decodes, and furthermore performs a D/A (digital/analogue) conversion on, a digital audio signal supplied from the reception unit **18**, and outputs the resultant signal to the AF amplification unit **13**.

The transmission unit **15** adds a header for radio communication to a digital audio signal supplied from the audio codec **14**, and also generates a packet for transmission as shown in FIG. **2**, based on an output from a PTT switch **27** described later. The configuration of the packet will be described later in detail, with reference to FIG. **2**. The transmission unit **15** furthermore modulates a carrier wave by using digital data contained in the packet, and transmits the resultant wave from the antenna **17** via the transmission/reception switching unit **16**.

The transmission/reception switching unit **16** delivers the transmission signal from the transmission unit **15** to the antenna **17** when the PTT switch **27** is pressed and turned ON, and delivers the reception signal of the antenna **17** to the reception unit **18** when the PTT switch **27** is released and turned OFF.

The reception unit **18** changes the reception frequency according to an instruction signal from the controller **21**, amplifies the reception signal obtained by tuning to the reception frequency, and furthermore, demodulates the resulting signal to reproduce a packet. Then, the reception unit **18** removes the header part from the reproduced packet, and supplies the audio data to the audio codec **14** and supplies the other data (e.g., packet data of an image signal, etc.) to the interface unit **19**.

The interface unit **19** is connected to an external device **31** (e.g., a personal computer or a smartphone) via an external connection terminal **20** and to a device **32** (e.g., a GPS receiver) that is built into the radio apparatus, and supplies packet data supplied from the external device **31** and the built-in device **32**, such as an image signal, to the transmission unit **15** and the controller **21**. The interface unit **19** also supplies packet data supplied from the reception unit **18**, to the external device via the external connection terminal **20**.

The controller **21** controls the operation of the radio apparatus **1**. The controller **21** includes a CPU (Central Processing Unit) **22**, a ROM (Read Only Memory) **23** storing a program operating on the CPU **22**, a RAM (Random Access Memory) **24** serving as a work memory for the CPU **22**, and a non-volatile memory **25** storing data such as a call sign.

The operation unit **26** conveys various sorts of inputs and user instructions to the controller **21**. The operation unit **26** includes the PTT (Push To Talk) switch **27** and a mode switch **33** that is for switching between communication modes. When the PTT switch **27** is pressed (turned ON), the transmission/reception switching unit **16** switches to the transmission mode and a transmission from the antenna **17** is performed, and when the PTT switch **27** is released (turned OFF), the transmission/reception switching unit **16** switches to the reception mode and the reproduction of the received audio signal is performed.

The display unit **28** includes a liquid crystal display or the like, and is used for displaying various sorts of data. The screen of the display unit **28** displays, for example, information indicating that the radio apparatus **1** has received amateur radio signals (there has been a call), and call signs or nicknames of the transmission source (the user's own station) and the transmission destination (the communication party station).

The radio apparatus **1** according to the present embodiment is also equipped with an audio encoder **29** for generating a beep sound, separately from the above-described general-purpose components. The audio encoder **29** generates coded data of a beep sound for notification to the user, and generates a beep sound according to an instruction from the controller **21**, and transmits the data of the beep sound to the transmission unit **15**.

Configuration of Packet

Next, with reference to FIG. **2** and FIG. **3**, a description is given of the configuration of a packet generated by the transmission unit **15**. The configuration of the packet shows the order and the grouping of a series of data pieces to be transmitted in digital audio communication.

As shown in FIG. **2**, a packet Pa includes a header part Ph and a data part Pd. The header part Ph includes a synchronization signal h**1**, a flag h**2**, a transmission destination

repeater call sign h3, a transmission source repeater call sign h4, a transmission destination call sign h5, and a transmission source call sign h6.

The synchronization signal h1 in the header part Ph is used for synchronization with the reception signal, and indicates the starting point of the signal. The flag h2 is data for indicating communication via a repeater, direct communication, a repeater control signal, etc., and is composed of a plurality of bits.

The transmission destination repeater call sign h3 is, for example, the call sign of a repeater station within the repeater area to which the transmission destination radio station belongs, and the transmission source repeater call sign h4 is a call sign of a repeater station within the repeater area to which the transmission source radio station belongs. The transmission destination call sign h5 is the call sign of the communication party station at the destination of the transmission, and the transmission source call sign h6 is the call sign of the user's own station. These call signs (h3 to h6) serve as identifiers for identifying the radio stations at the transmission destination and the transmission source, as well as the repeater stations that relay the radio signals. Note that the transmission destination call sign h5 may be CQ for making a call without the designation of any particular station.

In order to achieve the simultaneous transmission of data for audio communication and data for data communication, the data part Pd includes audio frames d1 and data frames d2, which are arranged one after the other, and a clearing frame d3 is attached to the end. Each of the audio frames d1 has a predetermined length, and a digitized audio signal is inserted into it. Each of the data frames d2 has a predetermined length, and data sets for data communication such as an image signal and a message are inserted into it. The clearing frame d3 indicates the end of the packet.

Note that the data frames d2 are periodically replaced with a resynchronization frame d4 (e.g. every 420 ms). A synchronization signal for synchronization with the radio apparatus of the communication party station is inserted into each resynchronization frame d4.

Next, with reference to FIG. 3, a description is given of data for data communication, which is to be inserted into the data frames d2. FIG. 3 shows the types of data to be inserted into each frame of the data part Pd. In this drawing, "audio" shows that audio signal data is inserted in the frame, and "data" shows that data for data communication is inserted in the frame.

Regarding the audio frames d1 and the data frames d2 constituting the data part Pd, the data amount of the audio frames d1 is set to be greater than the data mount of the data frames d2, because the transmission of audio signal data is given a high priority. Usually, 9 bytes of data is inserted into each of the audio frames d1, and 3 bytes of data is inserted into each of the data frames d2.

Furthermore, a mini-header d5, which includes the description of the data type, etc., is inserted in the beginning of the data frame d2. However, if the mini-header d5 is provided in every data frame, the amount of data that can be inserted in the data frame will be smaller, and therefore one mini-header d5 is inserted in one data frame out of every two data frames.

Therefore, as shown in FIG. 3 at the lower level, when generating the packet Pa, communication data for data communication is divided into 5-byte portions, and 1-byte mini-header d5 is added to the beginning of each portion so as to compose a data block, and after that, the data block is divided into 3-byte portions, and these portions are respectively inserted into two adjacent data frames d2.

Then, information indicating the data type and the data length is written into each mini-header d5. The data length indicates the length of the effective data inserted in a single data block. For example, suppose the case of transmitting general-purpose data having a data length of 13 bytes, such as image data. First, when the data to be transmitted is divided into 5-byte portions as described above, the data will be divided into three portions, namely 5-byte portion, 5-byte portion, and 3-byte portion. Then, the mini-header d5 is added to the beginning of each of these data portions. Here, if the information indicating the general-purpose data such as image data is 0×3 for example, the mini-header d5 added to each of the first and second data blocks is 0×35, and the mini-header d5 added to the third data block is 0×33.

The controller 21 (see FIG. 1) retrieves, via the interface unit 19, the data indicating the data type, etc., from the data for data communication transmitted from an external device (not shown in the drawings) connected to the terminal 20, and stores the retrieved data to the RAM 24. Also, when the transmission unit 15 generates packets for transmission, the controller 21 reads the aforementioned data from the RAM 24 and transfers it to the transmission unit 15. In the transferred data, the information indicating the data type is written into the mini-header d5.

Meanwhile, when reproducing the data for data communication from the packets Pa reproduced by the reception unit 18, the reverse of the aforementioned process is performed, i.e., based on the information in the mini-header d5, a 5-byte communication data portion is retrieved from the data contained in two data frames d2, the data for data communication is reproduced by concatenating the 5-byte communication data portions with each other, and the data for data communication is transmitted to an external device via the interface unit 19.

Operations for Communication in Slow Data Mode

As described above, the radio apparatus according to the present embodiment can perform communication in two modes, the slow data mode and the fast data mode. First, a description is given of the operations for communication in the slow data mode, with reference to FIG. 1 to FIG. 3.

The operation unit 26 has a mode switch 33 for switching between the communication modes, and the user can select either the slow data mode or the fast data mode by operating the switch 33. The slow data mode is selected when communication is performed with a conventional radio apparatus that has no option for a communication mode, or when no data for data communication needs to be transmitted, for example. Note that, the mode switch 33 may be other than the switch. For example, switching between the modes may be instructed from a menu screen displayed when a menu button or the like is pressed.

As a typical case where the slow data mode is used, the following describes the case where a radio apparatus (the user's own station) within a given area makes a call to a radio station (the communication party station) within another area.

FIG. 4 shows an arrangement of radio apparatuses and repeaters in a radio communication system according to the present embodiment. A radio communication system 100 includes at least two radio apparatuses 1 and at least one repeater 3. In the example shown in FIG. 4, radio apparatuses 1*a*, 1*b*, and 1*c* exist within an area 2*a* covered by a repeater 3*a*, and radio apparatuses 1*d* and 1*e* exist within an

area **2***b* covered by a repeater **3***b*. The adjacent repeaters **3***a* and **3***b* transmit audio and data in a multiplexed state to each other by using microwaves.

The following describes a case in which the radio apparatus **1***a* within the area **2***a* and the radio apparatus **1***d* within the area **2***b* communicate with each other. Before starting the communication, the user operates the operation unit **26** of the radio apparatus **1***a* in order to store, to the non-volatile memory **25**, information necessary for the communication, such as the call sign of the transmission source (the user's own station) and the call signs of the repeater stations.

When starting the communication, the user operates the operation unit **26** of the radio apparatus **1***a* in order to make a call with the designation of the call sign given to the transmission destination radio station and the call sign of the transmission destination repeater.

When the user presses the PTT switch **27**, the information input from the operation unit **26** is provided to the transmission unit **15** by the controller **21**, and the transmission unit **15** generates a packet according to an instruction form the controller **21**. As shown in FIG. **2**, the header part Ph of the packet Pa contains the call sign h**3** of the transmission destination repeater, the call sign h**4** of the transmission source repeater, the call sign h**5** of the transmission destination (the communication party station), and the call sign h**6** of the transmission source (the user's own station).

Within the data part Pd of the packet Pa, audio signal data output from the audio codec **14** is inserted into the audio frames d**1**, and data for data communication transferred from the interface unit **19** is inserted into the data frames d**2**.

The packet Pa generated and converted into radio signals by the transmission unit **15** are transmitted via the transmission/reception switching unit **16** and the antenna **17**. The packet Pa transmitted by the radio apparatus **1***a* (the user's own station) is relayed by the repeaters **3***a* and **3***b*, and reaches the radio apparatus **1***d* (the communication party station).

The radio signals received by the radio apparatus **1***d* (the communication party station) are provided to the reception unit **18** via the antenna **17** and the transmission/reception switching unit **16**, and are demodulated by the reception unit **18**, and thus the packet Pa is reproduced. Furthermore, the header part Ph is removed from the packet Pa reproduced by the reception unit **18**, and the data part Pd is provided to the audio codec **14** or the interface unit **19**, depending on the contents of the data part Pd.

Audio signal data provided to the audio codec **14** is decoded, and is furthermore converted into an analogue audio signal, and is then provided to the AF amplification unit **13**. The audio signal amplified by the AF amplification unit **13** is output from the speaker **12**, and thus the voice of the user of the transmission source is reproduced.

In contrast, the data for data communication obtained by demodulating the packet shown in FIG. **3** is transferred to the external device **31** via the interface unit **19**.

Furthermore, the packet Pa reproduced by the reception unit **18** is provided to the controller **21**. The CPU **22** of the controller **21** determines whether or not the packet Pa thus received is a valid packet, by performing ECC (Error Check Code) check, etc.

The CPU **22** stores, to the RAM **24**, the data in the header part Ph of the packet Pa determined to be valid, and also analyzes the information in the header part Ph. According to the results of the analysis, the CPU **22** displays, on the display unit **28**, the transmission destination call sign, the transmission source call sign, etc. of the received packet Pa.

Operations for Communication in Fast Data Mode

Next, with reference to FIG. **5**, FIG. **6**, and FIGS. **1** to **3** described above, a description is given of the operations for communication in the fast data mode. As described above, in the radio communication system according to the present embodiment, the radio apparatus **1** that has received radio signals is caused to output a beep sound at constant intervals from the speaker **12** in order to notify the user that communication is performed in the fast data mode.

FIG. **5** is a flowchart for the process performed by the controller **21** during the period from when the transmission of the packet Pa in the fast data mode is started to when it is stopped. FIG. **6** shows types of data to be inserted into the packet Pa generated by the transmission unit **15** during the same period.

Note that the descriptions of the operations that the user performs before starting the communication, such as the operation for storing the information necessary for the communication to the non-volatile memory **25**, the operation for designating the transmission destination call sign and the call sign of the transmission destination repeater, and so on are omitted, because they are the same as in the communication performed in the slow data mode.

There are two methods for switching to the fast data mode. The first method is the method by which the user switches the mode to the fast data mode by operating the mode switch **33** of the aforementioned operation unit **26**. This method is used, for example, in the case of transmitting data for data communication accumulated in an external device.

The second method is the method by which the controller **21** automatically switches the mode to the fast data mode when the controller **21** detects that data for data communication is transmitted from the external device **31** or the built-in device **32** to the interface unit **19** under the condition where the user is not pressing the PTT switch **27**, i.e., the user is not making an instruction to transmit an audio signal.

Regardless of which method is employed, the controller **21** transmits, to the transmission unit **15**, a command for starting a transmission in the fast data mode (Step S**1**).

Upon receiving from the controller **21** the command for starting the transmission, the transmission unit **15** starts generating the packet Pa. Specifically, as shown in FIG. **6**, the transmission unit **15** generates a packet in which data for data communication is inserted in each of the audio frames d**1** and data frames d**2**. The packet Pa thus generated is furthermore converted into high-frequency signals by the transmission unit **15**, and they are transmitted from the antenna **17**, as radio signals.

Note that when the fast data mode is selected by the second method, carrier sensing, which is for determining whether or not the transmission channel is used by any other stations, is performed before transmitting radio signals, in order to prevent the radio signals from colliding with other radio signals.

As described above with reference to FIG. **3**, when an audio communication and a data communication are simultaneously performed in the slow data mode, i.e., the communication mode in which audio signal data is inserted into audio frames, 9 bytes of audio signal data is inserted into each audio frame d**1**. Meanwhile, regarding data for data communication, a data block composed of a communication data portion d**6**, which is one of the divided 5-byte portions,

and the mini-header d**5** added to the beginning of the communication data portion d**6**, is divided into two portions, and these two portions are respectively inserted into two data frames d**2**.

In contrast, in the case of using both the audio frames and the data frames to transmit data for data commination in the fast data mode, i.e., the mode in which data for data communication is inserted into audio frames, the data to be transmitted is divided into 20-byte portions, and the mini-header d**5** and so on is added to each portion so as to compose a block, and the data of the block is divided and inserted into two adjacent audio frames d**1** and two adjacent data frames d**2**.

Specifically, each block is 24-byte data composed of 20-byte data for data communication, a 1-byte mini-header, 2-byte unique data to be inserted in each audio frame for abnormal noise reduction, and 1-byte date to be inserted into data frames in order to prevent the misdetection of packet loss, and this data block is divided and inserted into two adjacent audio frames d**1** (9 bytes×2) and two adjacent data frames d**2** (3 bytes×2).

If a comparison is made between the case of inserting the audio signal data into the audio frames d**1** of the packet Pa and the case of inserting the data for data communication into the audio frames d**1**, the communication speed of the latter case is approximately 3.5 times the communication speed of the former case, and the data for data communication can be transmitted at high speed in the latter case.

The following is a continuation of the description of FIG. **5**. When a first time period T**1** has elapsed since the controller **21** transmitted the command for starting the communication (Yes in Step S**2**), the controller **21** transmits to the audio encoder **29** a command for generating coded data of a beep sound, and furthermore, transmits to the transmission unit **15** a command for inserting the coded data of a beep sound into the audio frames d**1** (Step S**3**). Here, the first time period T**1** indicates the period of the cycle of beep sounds.

Upon receiving from the controller **21** the command for inserting a beep sound, the transmission unit **15**, as shown in FIG. **6**, waits until the breakpoint of the block of the data for data communication, and then inserts the data of a beep sound output from the audio encoder **29**, into the audio frames d**1**.

When a second time period T**2** shorter than the first time period T**1** has elapsed after the controller **21** transmitted, to the transmission unit **15**, the command for inserting a beep sound (Yes in Step S**4**), the controller **21** transmits to the transmission unit **15** a command for returning to the fast data mode, and also transmits to the audio encoder **29** a command for stopping the generation of a beep sound (Step S**5**). Here, the second time period T**2** indicates the period during which beep sounds are emitted.

Hereafter, returning to the original mode, the transmission unit **15** generates a packet in which data for data communication is inserted in each of the audio frames d**1** and data frames d**2**.

Subsequently, the controller **21** checks the reception status of the data for data communication received by the interface unit **19** (Step S**6**), and when the data reception is still continuing (No in Step S**6**), the process returns to Step S**2**, and the controller **21** repeatedly transmits the command for inserting the coded data of a beep sound to the transmission unit **15**, and the command for generating the coded data of a beep sound to the audio encoder **29**, at intervals of the first time period T**1**.

On the other hand, when the reception of the data for data communication by the interface unit **19** is interrupted at the end of the data (Yes in Step S**6**), the controller **21** transmits to the transmission unit **15** a command for stopping the transmission (Step S**7**). Upon receiving the command for stopping the transmission, the transmission unit **15** inserts the clearing frame d**3** into the packet Pa as shown in FIG. **6**, and stops the generation and transmission of packets.

Although not shown in the flowchart in FIG. **5**, when the user presses the PTT switch **27** during a communication in the fast data mode, the priority is given to the operation of the PTT switch **27**, and the controller **21** detects the signal from the operation unit **26** and switches the communication mode to the slow data mode.

Specifically, the controller **21** transmits to the transmission unit **15** a command for starting a transmission in the slow data mode, i.e., a command for inserting digital audio signals into the audio frames d**1**.

Upon receiving this command, the transmission unit **15** waits until the breakpoint of the block of the data for data communication, and inserts the digital audio signals supplied from the audio codec **14**, into the audio frames d**1**. As a matter of course, no beep sound is inserted into the packet Pa in the slow data mode.

Next, a description is given of a data reproduction method for a radio apparatus (the communication party station) that has received radio signals generated according to the procedure shown in FIG. **5** and transmitted by a radio apparatus (the user's own station). The controller **21** performs the process of reception data reproduction according to the flowchart shown in FIG. **7**.

The controller **21** retrieves the data in the data frames d**2** from the data of the packet Pa, which has been reproduced by the reception unit **18** from the radio signals, and then writes it into a built-in register (not shown in the drawing) (Step S**11**). The controller **21** analyzes the information in the mini-header d**5**, and determines whether or not the packet Pa is a packet transmitted in the fast data mode (Step S**12**).

As shown in FIG. **6**, in a communication in the fast data mode, data for data communication is inserted in the beginning of the data part Pd of the packet Pa and in the audio frames d**1** after the second time period T**2** has elapsed within the first time period T**1**.

When determining that the data for data communication is inserted in the audio frames d**1** (Yes in Step S**13**), the controller **21** instructs the reception unit **18** to retrieve the data for data communication (8 bytes in the present embodiment) from the audio frames d**1**, while excluding data for abnormal noise reduction (1 byte in the present embodiment) from the audio frames d**1** (Step S**14**).

Next, the controller **21** concatenates the data portions retrieved from two adjacent audio frames d**1** and two adjacent data frames d**2** in reverse order to how the block is created as described above, thereby reproducing the data for data communication (Step S**15**). The data for data communication thus reproduced is output to the interface unit **19**.

The controller **21** instructs the interface unit **19** to transfer the reproduced data for data communication to the external device (Step S**16**), and the interface unit **19** outputs the reproduced data for data communication to the external device according to the instruction. In this way, the data for data communication is transmitted with increased speed to the external device.

Meanwhile, as shown in FIG. **6**, the audio signal of a beep sound has been inserted in each audio frame d**1** of the packet Pa until the end of the second time period T**2** within the first time period T**1**. When determining that the beep sound data

is inserted in the audio frames d1 (No in Step S13), the controller **21** instructs the reception unit **18** to retrieve the beep sound data (9 bytes in this embodiment) contained in the audio frames d1 (Step S17).

Next, the controller **21** instructs the audio codec **14** to decode the beep sound data retrieved from the reception unit **18** (Step S18), and the audio codec **14** performs beep sound decoding according to the instruction from the controller **21**. The beep sound decoded and converted into an analogue audio signal is output from the speaker **12**.

Therefore, the user of the radio apparatus **1** (communication party station) that has received the radio signals can easily recognize that communication is performed in the fast data mode, from the sequences of beep sounds that are output in cycles of the first time period T1. This effect is beneficial particularly when a radio apparatus that does not support the fast data mode receives radio signals.

In parallel with Steps S17 and S18, the controller **21** concatenates the data portions retrieved from the data frames d2 and stored in the register, thereby reproducing the data for data communication (Step S19). The data for data communication thus reproduced is output to the interface unit **19**.

Next, the controller **21** performs the above-described Step S16, in other words instructs the interface unit **19** to transfer the reproduced data for data communication to the external device **31**, and the interface unit **19** outputs the reproduced data for data communication to the external device **31** according to the instruction.

In the above-described embodiment, it is preferable that the first time period T1, which indicates the period of the cycle of beep sounds, is approximately 1 second. Also, it is preferable that the second time period T2, which is the period during which beep sounds are emitted, is approximately 0.1 to 0.2 seconds, because the communication speed decreases if the second time period T2 is too long, and on the other hand it becomes hard to recognize the beep sounds if the second time period T2 is too short.

In the above-described embodiment, the audio encoder **29** is used for generating the beep sound. However, the means for generating the beep sound is not limited to this. The audio signal data in itself of the beep sound may be stored in the non-volatile memory **25**, and the controller **21** may read the data and transmit it to the transmission unit **15** during the second time period T2.

The following summarizes preferable examples of the embodiment of the present invention.

The data frame has a mini-header inserted therein, the mini-header containing information describing a data type, and the transmission unit writes, in the mini-header, the information indicating that data for data communication is inserted in the audio frame, as a portion of the information describing the data type.

In communication in the fast data mode, the transmission unit inserts notification sound data into the audio frame according to an instruction from the controller, at intervals of a first time period.

The radio apparatus further includes an audio encoder configured to generate coded notification sound data, and the audio encoder generates the coded notification sound data according to an instruction from the controller, and outputs the coded notification sound data to the transmission unit during a second time period that is shorter than the first time period.

The radio apparatus further includes an operation unit configured to input an instruction from a user to the controller, and even during communication in the fast data mode, the controller, upon receiving from the user via the operation unit an instruction to transmit an audio signal, instructs the transmission unit to switch to communication in a slow data mode that is a mode in which a digital audio signal to be transmitted is inserted into the audio frame.

In a situation where an instruction to transmit an audio signal is not input to the operation unit by the user, the controller instructs the transmission unit to perform communication in the fast data mode when receiving data for data communication from an external device or a device that is built into the radio apparatus.

The operation unit is provided with a mode switch that allows for selection of either the slow data mode or the fast data mode.

Although the present invention has been fully described by way of example with reference to the accompanied drawings, it is to be understood that various changes and modifications will be apparent to those skilled in the art.

Therefore, unless otherwise such changes and modifications from the scope of the present invention hereinafter defined, they should be construed as being included therein.

What is claimed is:

1. A radio communication system including at least two radio apparatuses,

each radio apparatus is configured to:

generate a packet including a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another, to insert audio signal data into the audio frame of the packet and to insert data other than the audio signal data into the data frame of the packet, and to thereafter convert the packet into a radio signal and transmit the radio signal; and

receive the radio signal, to reproduce a packet from the radio signal, to retrieve the audio signal data from the audio frame of the packet, and to retrieve the data other than the audio signal data from the data frame of the packet; and

each radio apparatus comprising:

an audio codec configured to generate a digital audio signal by performing A/D conversion and encoding on an analogue audio signal and to reproduce an analogue audio signal by performing decoding and D/A conversion on a digital audio signal; and

a controller configured to instruct the radio apparatus to generate a packet, and to reproduce a packet from a received radio signal,

wherein, when communication is performed in a fast data mode in which data for data communication to be transmitted, instead of audio signal data, is inserted in the audio frame,

the radio apparatus serving as a sender generates, according to an instruction from the controller, a packet in which data for data communication is inserted in the audio frame and the data frame, and information indicating that the data for data communication is inserted in the audio frame is further inserted in a predetermined position in the data frame, and

the controller serving as a recipient, which has received a radio signal, analyzes the information inserted in the predetermined position in the data frame of the packet reproduced, to determine that the data for data communication is inserted in the audio frame, and according to a result of the determination, retrieves data from

the audio frame and the data frame of the packet and reproduces the data for data communication.

2. The radio communication system according to claim **1**,

wherein the data frame has a mini-header inserted therein, the mini-header containing information describing a data type, and

the radio apparatus writes, in the mini-header, the information indicating that data for data communication is inserted in the audio frame, as a portion of the information describing the data type.

3. The radio communication system according to claim **1**,

wherein, in communication in the fast data mode, the radio apparatus inserts notification sound data into the audio frame according to an instruction from the controller, at intervals of a first time period.

4. The radio communication system according to claim **3**,

wherein the radio apparatus further comprises an audio encoder configured to generate coded notification sound data, and

the audio encoder generates the coded notification sound data according to an instruction from the controller, and outputs the coded notification sound data during a second time period that is shorter than the first time period.

5. The radio communication system according to claim **1**,

wherein the radio apparatus is further configured to input an instruction from a user to the controller, and

even during communication in the fast data mode, the controller, upon receiving from the user an instruction to transmit an audio signal, instructs the radio apparatus to switch to communication in a slow data mode that is a mode in which a digital audio signal to be transmitted is inserted into the audio frame.

6. The radio communication system according to claim **5**,

wherein, in a situation where an instruction to transmit an audio signal is not input to the operation unit by the user, the controller instructs the radio apparatus to perform communication in the fast data mode when receiving data for data communication from an external device or from a device that is built in the radio apparatus.

7. The radio communication system according to claim **5**,

wherein the radio apparatus is provided with a mode switch that allows for selection of either the slow data mode or the fast data mode.

8. A radio apparatus configured to generate a packet including a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another, to insert audio signal data into the audio frame of the packet and to insert data other than the audio signal data into the data frame of the packet, and to thereafter convert the packet into a radio signal and transmit the radio signal, the radio apparatus, comprising:

an audio codec configured to generate a digital audio signal by performing A/D conversion and encoding on an analogue audio signal; and

a controller configured to instruct the radio apparatus to generate a packet,

wherein, when communication is performed in a fast data mode in which data for data communication to be transmitted, instead of audio signal data, is inserted in the audio frame,

the radio apparatus generates, according to an instruction from the controller, a packet in which data for data communication is inserted in the audio frame and the data frame, and information indicating that the data for data communication is inserted in a predetermined position in the audio frame is further inserted in the data frame.

9. The radio apparatus according to claim **8**,

wherein the data frame has a mini-header inserted therein, the mini-header containing information describing a data type, and

the radio apparatus writes, in the mini-header, the information indicating that data for data communication is inserted in the audio frame, as a portion of the information describing the data type.

10. The radio apparatus according to claim **8**,

wherein, in communication in the fast data mode, the radio apparatus inserts notification sound data into the audio frame according to an instruction from the controller, at intervals of a first time period.

11. The radio apparatus according to claim **10**, further comprising an audio encoder configured to generate coded notification sound data,

wherein the audio encoder generates the coded notification sound data according to an instruction from the controller, and outputs the coded notification sound data during a second time period that is shorter than the first time period.

12. The radio apparatus according to claim **8**, further configured to input an instruction from a user to the controller,

wherein, even during communication in the fast data mode, the controller, upon receiving from the user an instruction to transmit an audio signal, instructs the radio apparatus to switch to communication in a slow data mode that is a mode in which a digital audio signal to be transmitted is inserted into the audio frame.

13. The radio apparatus according to claim **12**,

wherein, in a situation where an instruction to transmit an audio signal is not input by the user, the controller instructs the radio apparatus to perform communication in the fast data mode when receiving data for data communication from an external device or from a device that is built in the radio apparatus.

14. The radio apparatus according to claim **12**,

wherein the operation unit is provided with a mode switch that allows for selection of either the slow data mode or the fast data mode.

15. The radio apparatus according to claim **8**, further configured to receive the radio signal, to reproduce the packet from the received radio signal, to retrieve audio signal data from the audio frame of the packet, and to retrieve data other than the audio signal data from the data frame,

wherein, when a radio signal transmitted in the fast data mode is received,

the controller analyzes the information inserted in a predetermined position in the data frame of the packet reproduced, to determine that data for data communication is inserted in the audio frame, and according to a result of the determination, retrieves data from the audio frame and the data frame of the packet and reproduces the data for data communication.

16. A radio communication method for a radio communication system including at least two radio apparatuses, one of the at least two radio apparatuses being configured to generate a packet including a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a

data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another, and to convert the packet into a radio signal and transmit the radio signal, and another one of the at least two radio apparatuses being configured to receive the radio signal and reproduce a packet from the received radio signal, the radio communication method comprising the steps of:

with a radio apparatus serving as a sender,

generating a packet in which data for data communication is inserted in the audio frame and the data frame, and information indicating that the data for data communication is inserted in the audio frame is inserted in the data frame; and

converting the generated packet into a radio signal and transmitting the radio signal, and

with a radio apparatus serving as a recipient,

receiving the radio signal;

reproducing a packet from the received radio signal;

analyzing information that is inserted in the data frame of the reproduced packet to determine whether or not data for data communication is inserted in the audio frame; and

when determining that the data for data communication is inserted in the audio frame, retrieving data from the audio frame and the data frame of the packet and reproducing the data for data communication.

17. The radio communication method according to claim **16**, further comprising the steps of:

with the radio apparatus serving as a sender, inserting notification sound data into the audio frame at intervals of a first time period and generating a packet, and

with the radio apparatus serving as a recipient, reproducing a packet,

retrieving notification sound data from the audio frame of the reproduced packet,

converting the notification sound data into an analogue audio signal, and outputting the analogue audio signal from a speaker.

18. A packet generation method for a radio apparatus that performs communication with another radio apparatus by using a packet that includes a header part containing identifier data identifying at least a transmission destination radio station and a transmission source radio station; and a data part in which an audio frame and a data frame, each having a predetermined length, are consecutively arranged one after another, the packet generation method comprising the steps of:

with the radio apparatus,

determining whether or not the communication is performed in a fast mode;

inserting data for data communication into the audio frame and the data frame; and

inserting, into a predetermined position in the data frame, information indicating that the data for data communication is inserted in the audio frame, and

when communication is performed in a fast data mode in which data for data communication to be transmitted, the data for data communication is inserted in the audio frame instead of audio signal data.

19. The packet generation method according to claim **18**, further comprising the step of inserting notification sound data for notifying the user that communication is performed in the fast data mode by audible sound into the audio frame at intervals of a first time period.

20. A method for reproducing data from a packet performed by a radio apparatus that is configured to receive a radio signal containing a packet generated by the packet generation method according to claim **18**, and to reproduce the packet from the radio signal, the method comprising the steps of:

analyzing information that is inserted in the data frame of the reproduced packet to determine whether or not data for data communication is inserted in the audio frame; and

when determining that the data for data communication is inserted in the audio frame, retrieving data from the audio frame and the data frame of the packet and reproducing the data for data communication.

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